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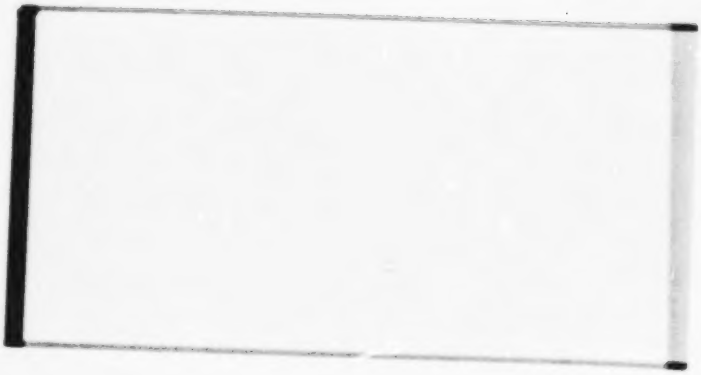

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METHODS OF ATTRACTING FISH TO A HIDROSTAL PUMP

Report No 83-142-K

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ABSTRACT

Filtered mercury vapour light alone and in combination with other treatments (strobe lights, electric fields, and a bubble curtain) significantly improved the efficiency with which a Hidrostal pump captured smelt and alewife. Significant differences in capture efficiency were not apparent among tests employing mercury vapour lights alone or in combination with other treatments. The efficiency of capture of alewife was significantly higher than that of smelt. Capture efficiency did not vary significantly among alewife on a normal and a reverse photoperiod.

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To Dr. W.R. Effer
Manager
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and Assessments

METHODS OF ATTRACTING FISH TO A HIDROSTAL PUMP

D.W. Rodgers

INTRODUCTION

The Hidrostal pump is currently being considered by Ontario Hydro for systems designed to transport entrapped fish from station forebays to the adjacent waterbody without damaging the fish. The Hidrostal pump has been shown to be effective in transporting live fish with little apparent injury (Patrick, 1982a) but even in laboratory tests, difficulties were experienced in directing fish into the pump intake. At the request of Environmental Studies and Assessments, the Biological Research Section tested methods of attracting and concentrating fish for transport with the Hidrostal pump. This study was conducted as part of the overall capitalized once through cooling program for 1982.

Potential mechanisms for attracting and concentrating fish include lights, water currents, electric fields and olfactory lures. The strong currents encountered in station forebays largely preclude the use of water currents and olfactory cues in directing fish at operating generating stations. Filtered mercury vapour lighting appeared to be effective in concentrating fish in the immediate vicinity of the light source in both field and laboratory tests (Patrick, 1982b; Haymes, 1982). Accordingly, filtered mercury vapour lighting was used as the primary fish attractant in the present study. Strobe lighting and bubble curtains may produce strong avoidance reactions in fish (Patrick, 1981; Patrick, 1982c) and were used intermittently to provide additional cues for directing fish into the pump intake. Similarly, as electric fields may either attract or repel fish, depending on the field strength (Vibert, 1967), electric fields were also employed as a secondary factor for directing fish to the Hidrostal pump. Experiments were conducted using two representative Great Lakes fish: rainbow smelt (*Osmerus mordax*) and alewife (*Alosa pseudoharengus*) which are commonly impinged at Ontario Hydro generating stations.

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MATERIALS AND METHODS

1.0 Fish Collection and Maintenance

Adult smelt and alewife (∿10-15 cm total length) were collected by beach seine from Lake Ontario and transported to the laboratory in oxygenated containers. In the laboratory, fish were maintained in aerated holding tanks supplied with dechlorinated Lake Ontario water. Average water temperatures were 12-15°C in June and 15-18°C in July and August. Fish were held for at least 2 weeks prior to experiments and were normally used within the next 2-4 weeks. Alewife were fed tetramin and oatmeal; smelt were not fed as they did not accept artificial diets. Fish were subject to a controlled natural photoperiod of 16 h light and 8 h dark. Fish under "reverse photoperiod" were also subject to a 16 L - 8 D photoperiod with the dark interval shifted to the normal day (8:30 - 16:30). Fish were maintained under the reverse photoperiod light regime for at least 2 weeks prior to testing.

2.0 Experimental Apparatus and Testing

The Hidrostal pump and test pool have been previously described in detail (Patrick, 1982a). Briefly, tests were conducted in a rectangular concrete pool (12 x 6 x 1 m) with the Hidrostal pump (Model H5) mounted on a divider wall. The intake and discharge pipes (∿25 cm in diameter) of the pump extended approximately 2 m on either side of a divider wall (Figure 1). A mesh fence (1 cm square) extended perpendicularly from the side walls, then angled to the pump intake (Figure 1). A filtered mercury vapour light (250 W clear mercury bulb with blue plastic filters) was placed immediately behind the pump intake. The anode (1 m diameter, 6 mm aluminum) of a Smith-Root Type VI-A Electrofisher encircled the pump intake, while the cathode (3-2 m corrugated galvanized tubes, 5 cm in diameter) was placed parallel to the back wall of the pool, approximately 3 m from the anode. Two Tandy strobe lights were attached to the angled walls of the mesh fence, approximately 1.5 m from the pump intake (Figure 1). These lights were operated at a frequency greater than 200 flashes per minute with a flash peak duration of less than 100 µs. The pump intake was encircled by a 3 m length of 5 cm diameter porous hose filled with glass beads. This bubble wand was connected to a source of compressed air and generated a bubble curtain.

Fish transported through the Hidrostal pump were retained in a mesh (1 cm square) receiving cage at the discharge. Water pumped through the pump to the discharge side of the pool returned to the intake side across the overflow divider wall (Figure 1). The pool was supplied with dechlorinated Lake Ontario water and maintained at a depth of approximately 1 m. During the pump tests, inflow to the pool was stopped.

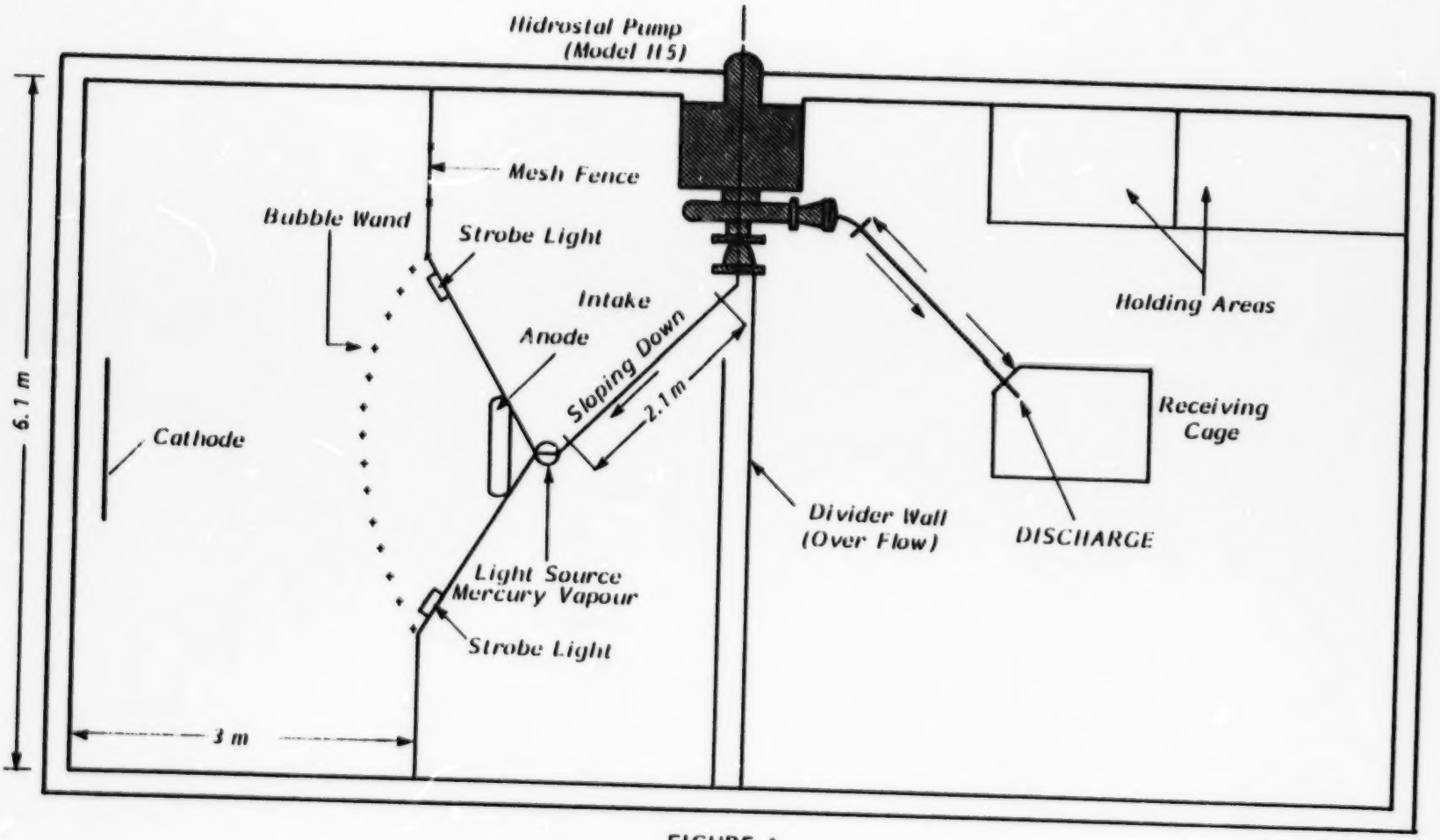

FIGURE 1

GENERAL LAYOUT OF HIDROSTAL PUMP ASSEMBLY

Overhead fluorescent lights were kept off while fish were in the test pool. Light levels at a depth of 0.5 m were less than 0.5 lux (as measured by photometer - Radiometer model L1-185A). When the mercury vapour light was employed, light intensities were approximately 5 lux in the immediate vicinity of the intake but decreased to less than 1 lux within 2 m of the intake (Figure 2). In this same 2 m zone, maximum light intensities were 1 lux or greater when both mercury vapour and strobe lights were employed (Figure 3). In preliminary observations with the electroshocker, it was noted that fish responded to square wave DC pulses of 1 ms duration of 168 V operated intermittently with 2 s pulses followed by a 2 s pause between electrical stimuli, without apparent distress as was observed at higher voltages and with alternating current. Accordingly, the electroshocker was used at these settings in all tests. At these settings, the electric field was approximately 15-20 µamp/30 cm between electrodes and decreased towards the periphery of the pool (Figure 4). (Electric field was measured with a probe of 2 wires, 30 cm apart and connected to a Beckman digital multimeter.) Water velocity as measured with an Ottmeter was approximately 10 cm/s in the immediate vicinity of the intake but was less than 5 cm/s within 0.5 m of the intake.

For each test, a group of 25 smelt or alewife were introduced to the intake side of the test pool at approximately 15:00 the day before the test. The Hidrostal pump was primed and started at approximately 09:00 the next morning. The pump was run at a speed of approximately 600 rpm, which is within the range of speeds recommended for minimal damage to fish (Patrick, 1982a). After three hours, the pump was shut-off and the fish in the discharge receiving cage counted. Fish were then transferred to a holding cage for 24 h and mortality noted. Fish which passed through the pump were not subsequently reused.

In tests employing the mercury vapour light, the light was used continuously over the three hour test interval. Other treatments (strobe lights, electroshocker and bubble curtain) were only tested in conjunction with the mercury vapour light as preliminary tests indicated that these treatments by themselves were ineffective in increasing passage of fish through the pump. Commencing 57 minutes after the test was started, these treatments were applied for a 3 minute interval; treatments were subsequently repeated every 15 minutes for the duration of the test.

Smelt were tested without any attractants (pump alone) and with the mercury vapour light alone and in combination with the electroshocker, strobe lights and both treatments simultaneously. Alewife under normal and reverse photoperiod light regimes were tested without attractants and with the mercury vapour light alone and in combination with the electroshocker, strobe lights and bubble

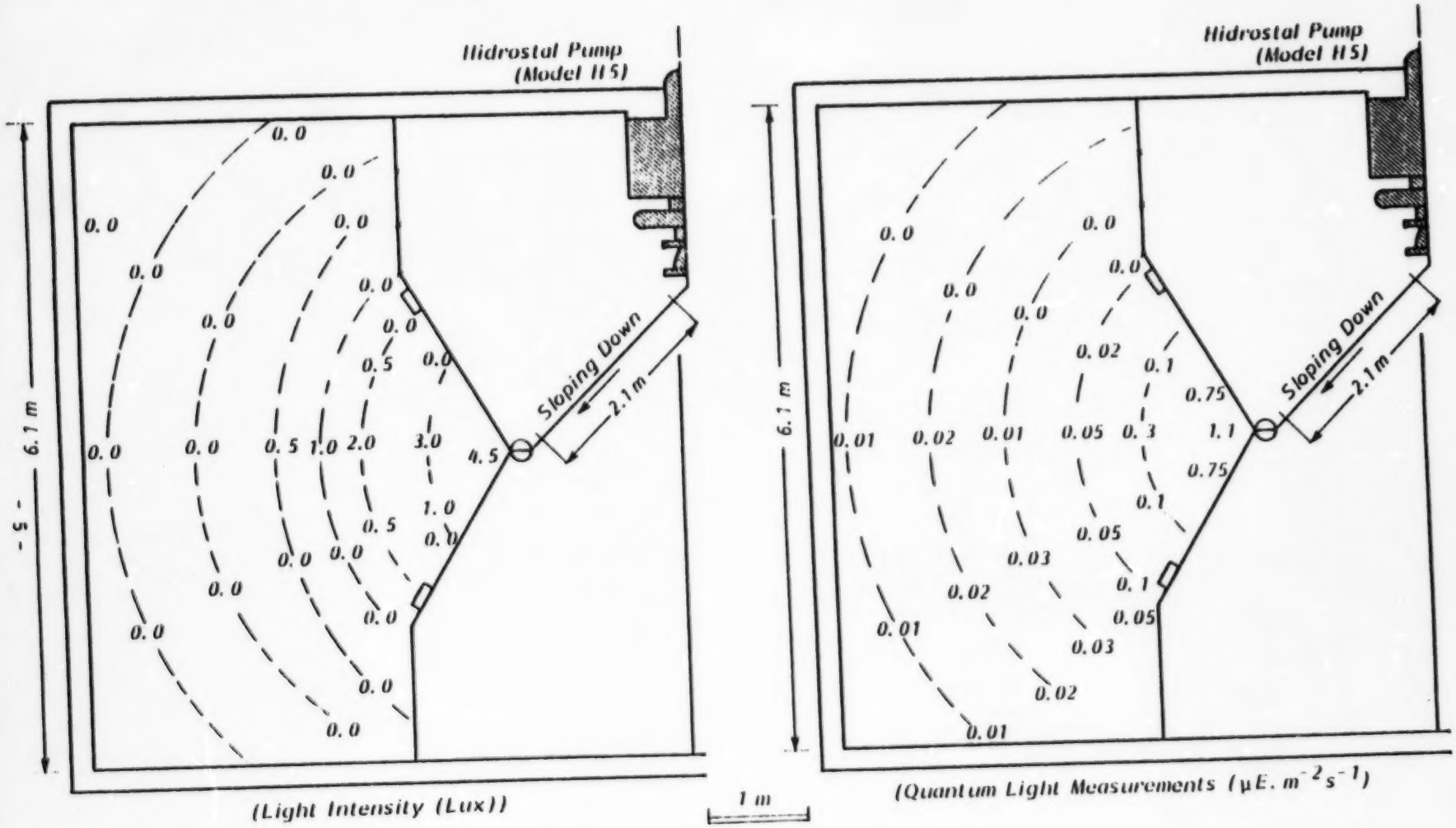

FIGURE 2

LIGHT INTENSITY IN EXPERIMENTAL POOL WHEN MERCURY VAPOR LIGHT IS ON

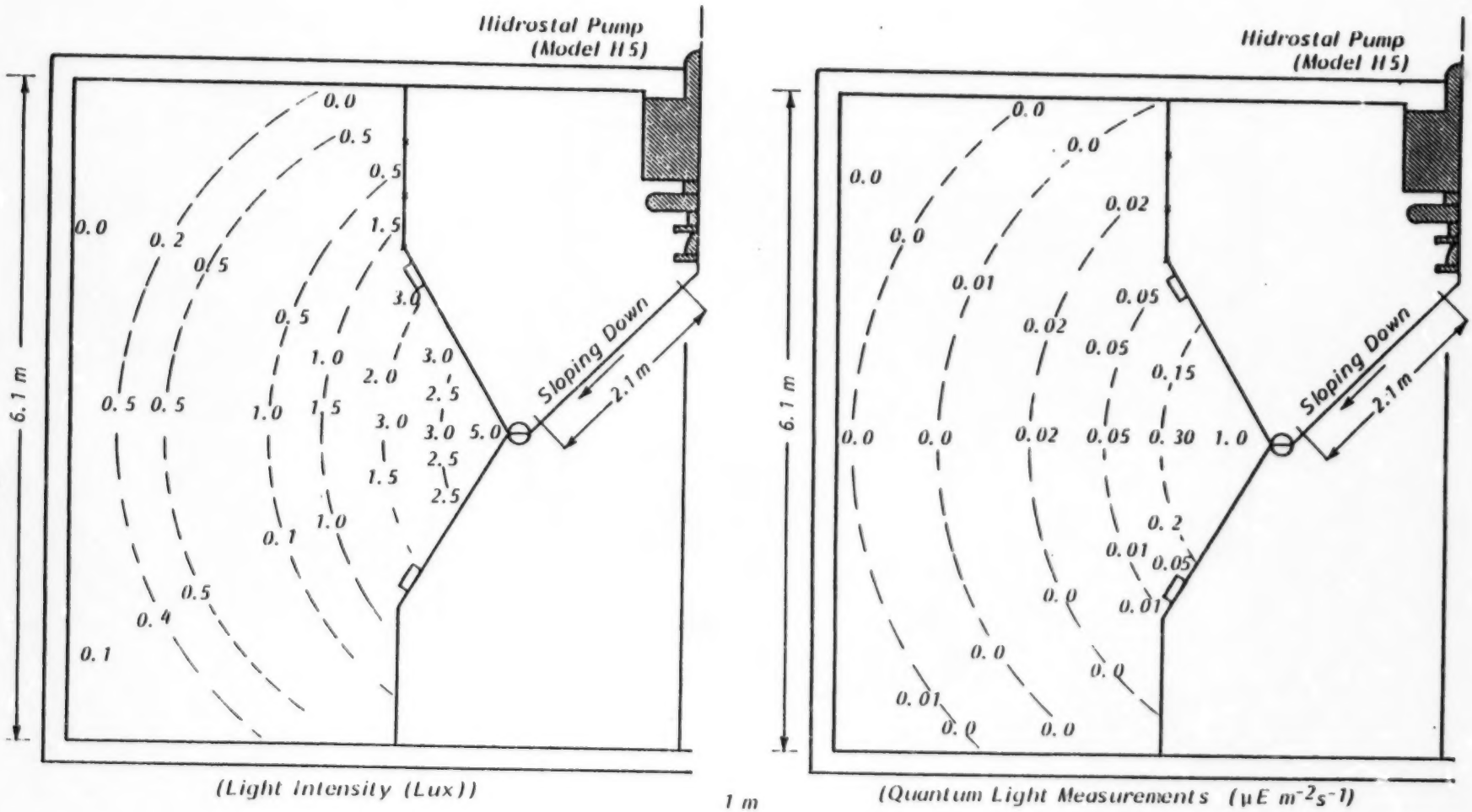

FIGURE 3

LIGHT INTENSITY IN EXPERIMENTAL POOL WHEN MERCURY VAPOR LIGHT AND STROBE LIGHTS ARE ON

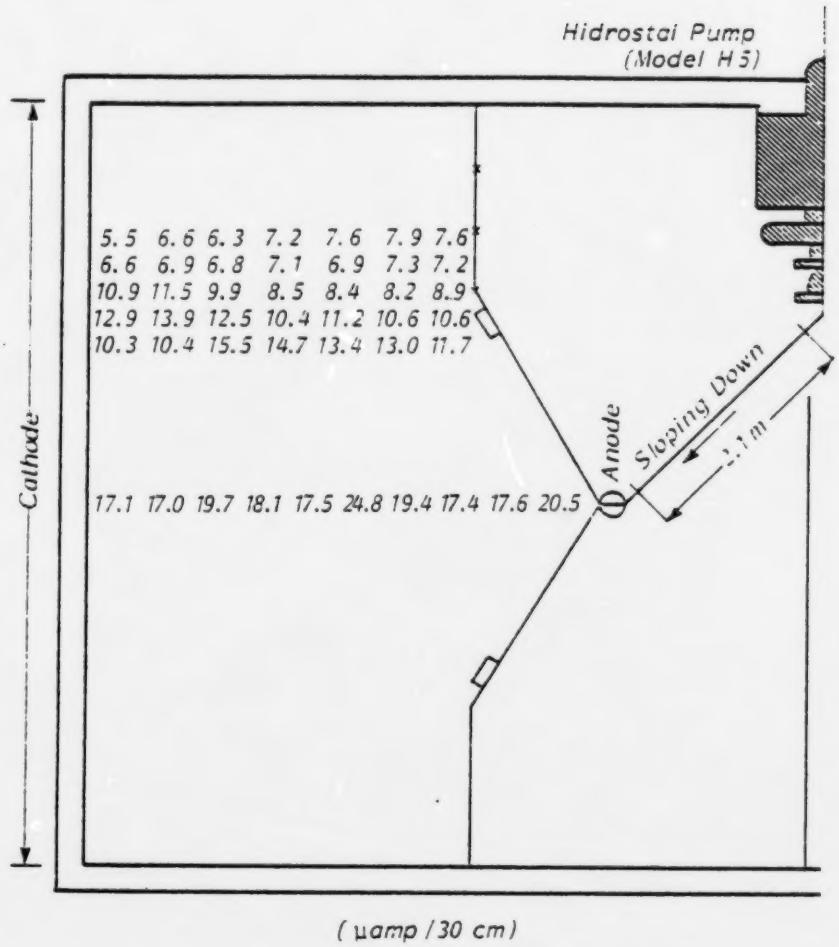

FIGURE 4

ELECTRICAL FIELD IN EXPERIMENTAL POOL
WHEN ELECTROSHOCKER IS ON

curtain. Alewife under normal photoperiod were also tested with the mercury vapour light in combination with electroshocker and strobe lights, electroshocker and bubble curtain, strobe lights and bubble curtain and all three treatments simultaneously. At least two replicate trials of each treatment were conducted, with the order of treatments within a replicate randomized.

Data were analyzed using the appropriate fixed-effects analysis of variance model. If the F was significant ($p < 0.05$), cell means were compared at $p < 0.05$ using the Student-Neuman-Keuls procedure. Similar results were obtained in analysis with untransformed and arc sine transformed data.

RESULTS AND DISCUSSION

The Hidrostal pump by itself was not effective in capturing either smelt or alewife (Table 1). For both fish species, capture efficiency improved significantly ($p \leq 0.05$) when the pump was used in conjunction with the filtered mercury vapour light and other treatments (Table 1). Significant differences in capture efficiency were not apparent, however, among tests employing the mercury vapour light alone or in combination with other treatments.

The low capture efficiency of the Hidrostal pump alone is consistent with the observation that fish actively avoided the pump intake in preliminary tests of the effectiveness of the Hidrostal pump (Patrick, 1982a). The increased efficiency of capture obtained when the pump was operated in conjunction with the mercury vapour light is consistent with observation that mercury vapour lights were effective in attracting fish in both the laboratory (Patrick, 1982b) and field (Haymes, 1982).

The inability to discriminate among tests employing the mercury vapour light and other treatments appears to derive largely from the high variability in capture efficiency among replicate trials (Appendices 1 and 2). There were, however, no obvious interactions among treatments in detailed tests with alewife under normal photoperiod (Figure 5). Both smelt and alewife normally swim in schools (Emery, 1973), which likely contributes substantially to the observed high variability in capture efficiency. Fish in a school tend to respond as a unit rather than as individuals (Partridge, 1982), thus capture becomes an all or nothing response with either many or few fish caught in a given trial.

In field tests at Nanticoke Generating Station, mercury vapour lights in combination with strobe lights appeared to increase capture efficiency of a modified tempering pump when compared with control trials without lights (Haymes, 1982). In these field tests, catches using mercury vapour lights in combination with strobe lights were not directly compared with catches using mercury vapour

TABLE I. Mean Number of Fish Captured by Hidrostal Pump (Number of Replicates in Parentheses; n = 25 Fish/Test)[1]

		Alewife	
	Smelt[2]	Normal Photoperiod	Reverse Photoperiod
Pump Alone	0.5(2) a	1.7(3) a	2.5(2) a
Mercury Vapor Light (MVL)	4.5(2) b	15.3(3) b	17 (2) b
MVL + Strobe Lights (STR)	5.3(3) b	11.7(3) b	11 (2) b
MVL + Electroshocker (ELC)	8.5(2) b	14.3(3) b	12 (2) b
MVL + Bubble Curtain (BC)	-	17 (3) b	13.5(2) b
MVL + STR + ELC	8.5(2) b	18.3(3) b	-
MVL + STR + BC	-	10.3(3) b	-
MVL + ELC + BC	-	11.7(3) b	-
MVL + STR + ELC + BC	-	15 (3) b	

(1) Detailed results of individual trials are given in Appendices 1 and 2.

(2) Means with different letter subscripts differ significantly ($P < 0.05$) when compared using SNK procedure. Means were compared only if F was significant ($p < 0.05$) in a one-way analysis of variance within species and photoperiod.

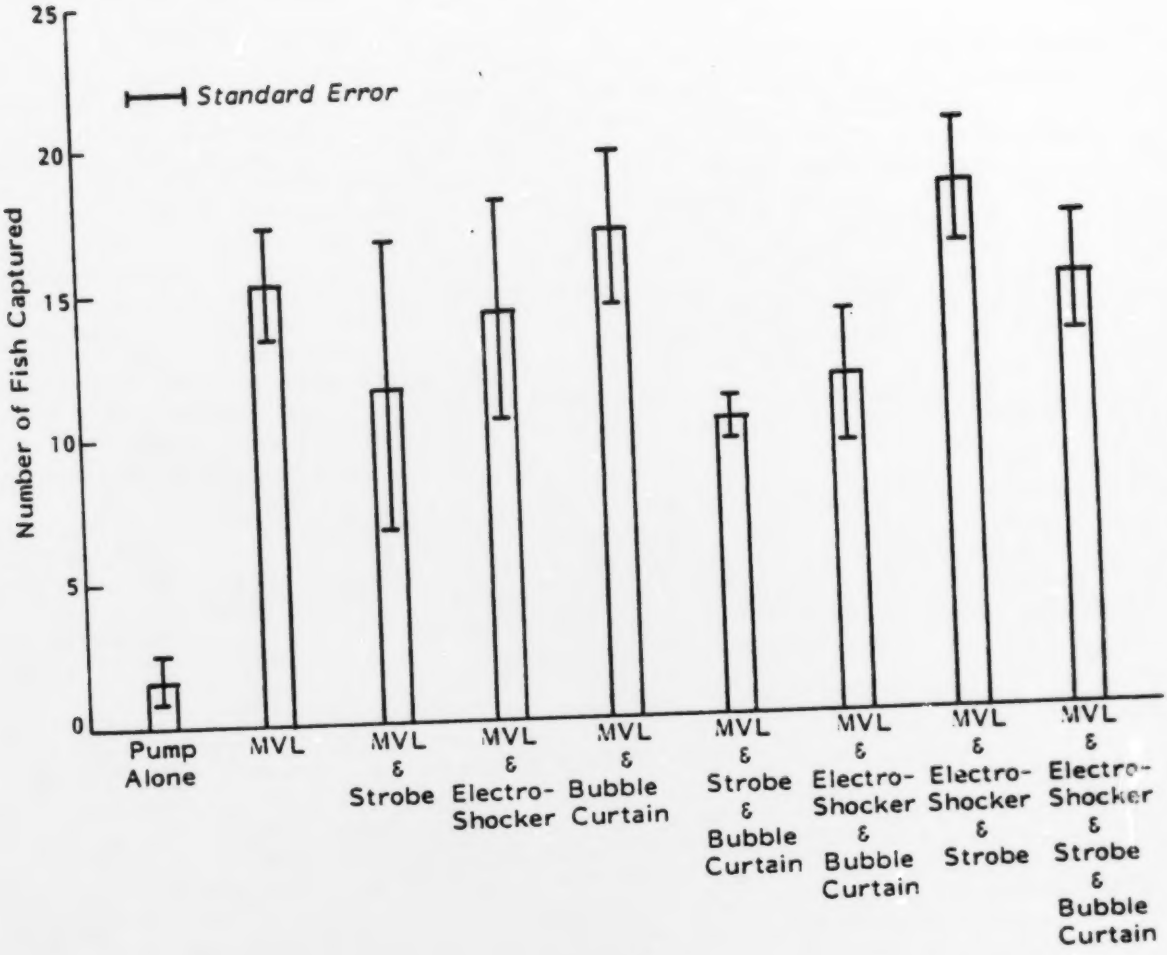

FIGURE 5

CAPTURE EFFICIENCY OF HIDROSTAL PUMP FOR ALEWIFE
(NORMAL PHOTOPERIOD - 3 REPLICATES PER TREATMENT,
MVL - MERCURY VAPOR LIGHT)

lights alone. The intensity of strobe lights in this study was below the 10 lux recommended by Patrick (1981). Further tests using higher intensity strobe lighting are currently underway.

The efficiency of capture of alewife was significantly greater than that of smelt (Figure 6), although the general pattern of response was similar for both species. The higher capture efficiency obtained for alewife in tests with the mercury vapour light is not consistent with previous observations that when compared with alewife, smelt oriented more readily to mercury vapour light and spent more time in the vicinity of the light (Patrick, 1982b). Present results are consistent with earlier observations that alewife, but not smelt, displayed a weak positive phototaxis in tests of swimming performance (Griffiths, 1979). Because of the marked differences in response among fish species the efficiency of the Hidrostal pump in the field may vary with the species composition of the entrapped fish. Further tests, with another commonly impinged species, gizzard shad (*Dorsoma cepedianum*) are planned if fish are available.

Capture efficiency did not vary significantly between alewife on normal and reverse photoperiods (Figure 7). This suggests that the pump with attractants would be effective in capturing fish in natural photoperiods. In the field, fish have distinct habits of diurnal, crepuscular and nocturnal activity (Emery, 1973) which could markedly affect their susceptibility to capture.

For smelt, mortality over the twenty-four hours subsequent to passage through the pump was low - 7 of 60 fish (Appendix 1). Mortality of alewife was higher (155 of 458 fish - Appendix 2) but was exceedingly variable, ranging from 0 to greater than 50% and did not appear related to specific treatments (Appendix 2). Dead alewife normally exhibited extensive loss of scales which appeared to result from abrasion of the fish against the wire mesh receiving cage either when the fish were discharged or in subsequent confinement. In previous tests, without this restraining cage, passage through the Hidrostal pump did not significantly increase mortality of a number of fish species, including alewife (Patrick, 1982). Consequently, the mortality observed in present tests may be an artifact caused by the restraining cage and may not apply in field operations.

CONCLUSIONS

1. Filtered mercury light alone and in combination with other treatments (strobe lighting, electric fields and a bubble curtain), significantly improved the efficiency with which a Hidrostal pump captured smelt and alewife. Significant differences in capture efficiency were not apparent among tests employing the mercury vapour light alone or in combination with other treatments.

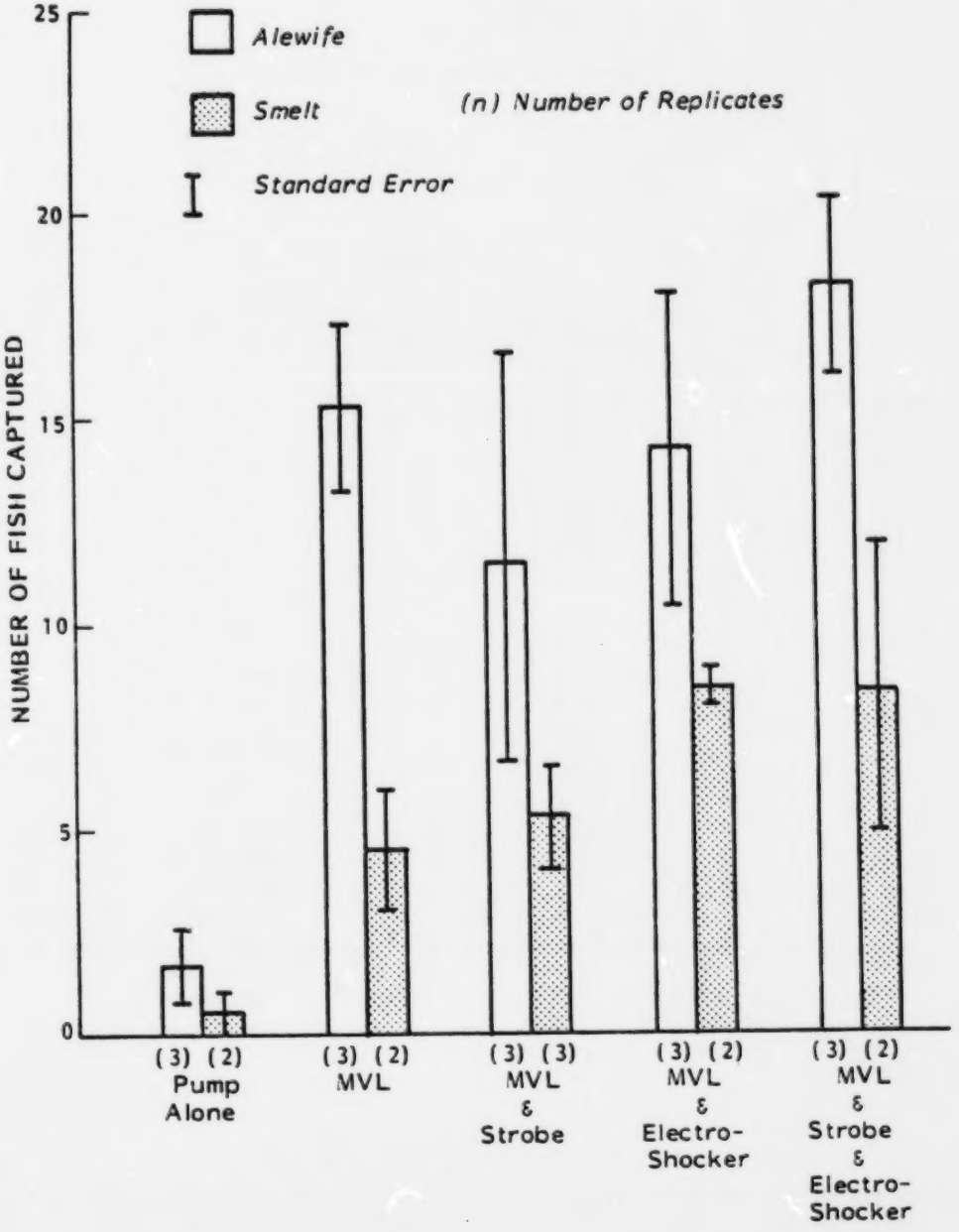

FIGURE 6

CAPTURE EFFICIENCY OF HIDROSTAL PUMP FOR SMELT AND ALEWIFE
(MVL - MERCURY VAPOR LIGHT)

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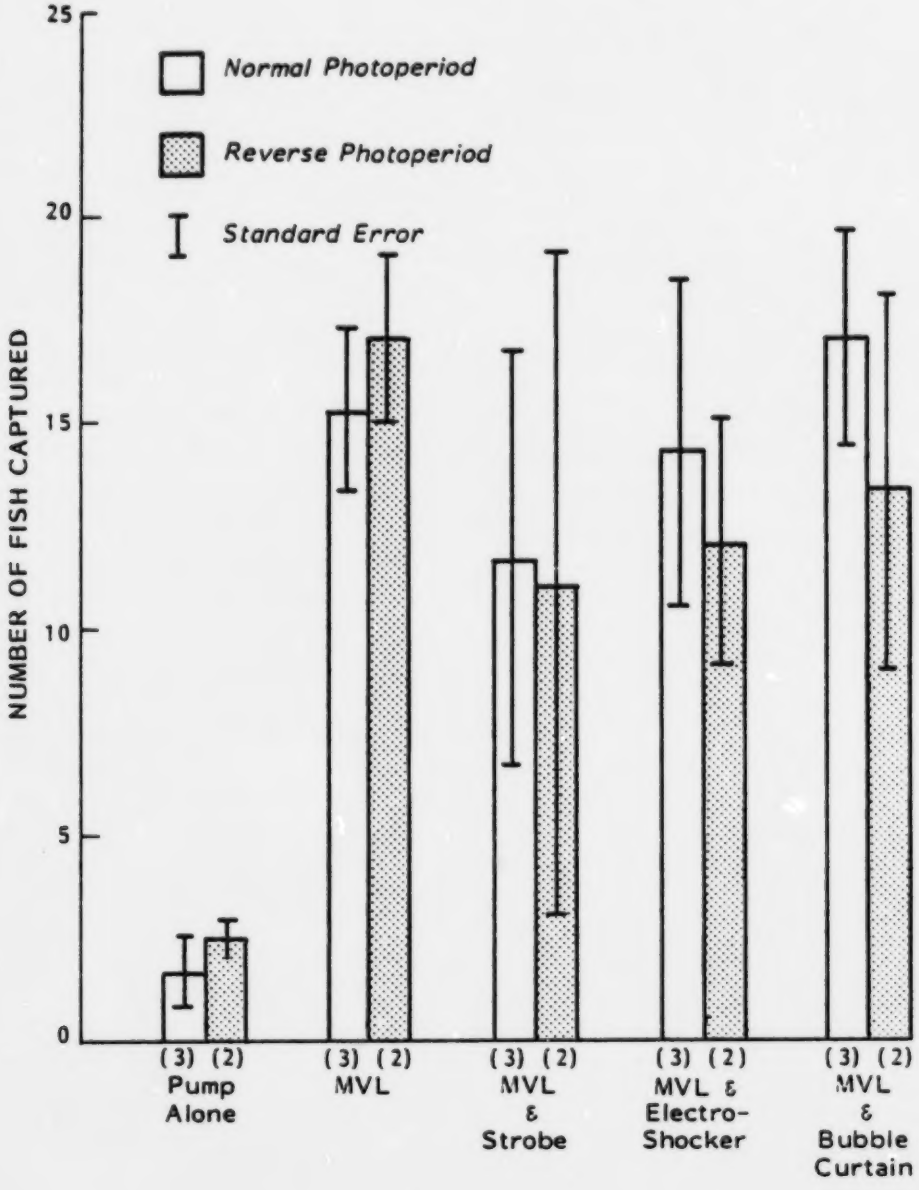

FIGURE 7

CAPTURE EFFICIENCY OF HIDROSTAL PUMP FOR ALEWIFE IN NORMAL AND REVERSE PHOTOPERIOD LIGHT REGIMES (MVL - MERCURY VAPOR LIGHT)

2. The efficiency of capture of alewife was significantly greater than that of smelt suggesting that the efficiency of the pump in the field may vary with species composition of entrapped fish.

3. Capture efficiency did not vary significantly between alewife on normal and reverse photoperiods.

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REFERENCES

Emery, A.R. 1973. Preliminary comparisons of day and night habits of freshwater fish in Ontario Lakes. J. Fish Res Board Can. 30: 761-774.

Griffiths, J.S. 1979. Effects of size and temperature on sustained swimming speeds of Great Lakes Fish. Ontario Hydro Research Division Report No. 79-362-K.

Haymes, G.T. 1982. Use of filtered mercury vapor lights in association with a modified fish handling pump at Nanticoke TGS. Ontario Hydro Research Division Report No. 82-165-K.

Partridge, B.L. 1982. The structure and function of fish schools. Sci Amer 246 (6): 114-123.

Patrick, P.H. 1981. Responses of fish to diversion barriers. Ontario Hydro Research Division Report No. 81-190-K.

Patrick, P.H., 1982a. Effectiveness of a Hidrostal pump and transport system in the live transfer of fish. Ontario Hydro Research Division Report No. 82-295-K.

Patrick, P.H., 1982b. Responses of alewife and smelt to filtered mercury vapor light. Ontario Hydro Research Division Report No. 82-288-K.

Patrick, P.H., 1982c. Responses of fish to air bubble barriers. Ontario Hydro Research Division Report No. 82-362-K.

Vibert, R., 1967. [ed] Fishing with Electricity, Its Applications to Biology and Management. Fishing News (Books) Ltd., London. 276 p.

APPENDIX 1

EFFICIENCY OF CAPTURE OF SMELT BY HIDROSTAL PUMP
(NUMBER OF FISH PASSED OF 25: SUBSEQUENT 24 H
MORTALITY GIVEN IN PARANTHESES)

Treatment	Replicate 1	2	3
Pump Alone	0	1 (0)	-
Mercury Vapour Light (MVL)	3 (0)	6 (0)	-
MVL + Strobe Lights (STR)	4 (1)	4 (2)	8 (1)
MVL + Electroshocker (ELC)	8 (0)	9 (1)	-
MVL + STR + ELC	5 (1)	12 (1)	-

APPENDIX 2

Efficiency of Capture of Alewife by Hidrostal Pump
(Number of Fish captured of 25; subsequent 24 h mortality given in Parentheses)

Treatment	Normal Photoperiod Replicate 1	Normal Photoperiod Replicate 2	Normal Photoperiod Replicate 3	Reverse Photoperiod Replicate 1	Reverse Photoperiod Replicate 2
Pump Alone	3 (2)	2 (1)	0	2 (0)	3 (1)
Mercury Vapor Light (MVL)	12 (5)	15 (1)	19 (13)	15 (7)	19 (7)
MVL + Strobe Lights (STR)	14 (3)	19 (2)	2 (2)	3 (0)	19 (1)
MVL + Electroshocker (ELC)	7 (3)	16 (9)	20 (10)	15 (5)	9 (2)
MVL + Bubble Curtain (BC)	18 (1)	21 (2)	12 (5)	9 (1)	18 (11)
MVL + STR + ELC	20 (10)	21 (5)	14 (6)	-	-
MVL + STR + BC	9 (4)	11 (4)	11 (6)	-	-
MVL + ELC + BC	11 (0)	16 (4)	8 (5)	-	-
MVL + STR + ELC + BC	14 (1)	19 (3)	12 (9)	-	-

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